JOURNAL

OF

SOUTH AFRICAN BOTANY

VOL. XV.

DEVELOPMENT OF THE EMBRYOSAC OF *RESTIO DODII* AND *ELEGIA RACEMOSA*.

By Bessie Borwein, B.Sc. Hons. (Rand); Millicent L. Coetsee, B.Sc. Hons. (Rand); and S. Krupko, Ph.D. (Warsaw).

I. Introduction.

As far as the authors are aware these are the first studies on the megagametophyte of the Restionaceae. The Restionaceae is an interesting family of plants limited chiefly to South Africa and Australia. Only one representative of the family is found in South America and South Asia (Engler and Prantl) (1). In South Africa they are confined chiefly to the south-west region of the Cape Province where they are very abundant. Wettstein (11) regards the Cape Province as the probable place of origin of the family and it is certainly in the Cape that the largest variety of genera and species occur.

II. Methods.

The material was collected and fixed by Dr. S. Krupko in December, 1946 and January, 1947 in the Cape Peninsula. The ovaries were freed of their scales, cut at their bases and across the stigmas to ensure rapid penetration of the fixatives. Fixatives used were Stockholm's modification of Navashin, Fleming Strong and acetic Carnoy. Some material was pretreated with Carnoy for ten seconds before fixing in Navashin. Navashin gave the most satisfactory fixation. Much of the material was plasmolysed in spite of the use of a vacuum pump.

Dehydration was carried out by the Xylol method. Sections were cut on a rotary microtome at thicknesses varying from 8μ to 20μ, most often at 10μ. Two percent alc. Iron-haematoxylin and Newton's gentian-violet were the stains used. Brief staining in dilute Congo-red after alum differentation in the former case, showed up the cellulose walls of the nucellus, especially the chalaza, very clearly. Material fixed in Fleming was bleached in a mixture of half 50 per cent. alc. plus half H_2O_2 for 15 to 30 mins. Xylol balsam was used for mounting.

Eighty-eight ovaries of *Restio dodii* and 183 of *Elegia racemosa* were sectioned, this being the total number available to the authors in Johannesburg.

III. TERMINOLOGY.

Terminology used is that described and recommended by Maheshwari (1937) (2). For taxonomic descriptions of the South African Restionaceae the reader is referred to the works of N. S. Pillans of the Bolus Herbarium, Cape Town (5, 6, 7).

IV. OBSERVATIONS.

A. In both *Elegia racemosa* and *Restio dodii* the embryosac development was found to correspond to the normal type (Schnarf (9), Maheshwari (2, 3, 4).) The small differences between the two are dealt with in the following discussion.

B. **Elegia racemosa.**

Megasporogenesis. Nucellar differentiation was observed only in *Elegia racemosa.* The nucellar tissue appears as a small more or less oval area of cells at the base of the stigmas. These cells stain more darkly than the surrounding tissue and their cytoplasm appears denser. Only in the youngest buds where flower parts are not yet distinguishable is no nucellar tissue found. The area occupied by the cells of the nucellus varies according to the stage of differentiation. Where the bracts and stigmas are distinguishable, the nucellar tissue was found to be approximately 60μ long, 55μ wide and 42μ deep.

The megaspore mother-cell arises in the layer directly beneath the nucellar epidermis. The megaspore mother-cell is distinguishable from the surrounding cells by its increased size, large nucleus and less dense cytoplasm. (Fig. 1). The developmental stage of the ovule varies a good deal in the presence of the megaspore mother-cell. In some of the cases observed the integuments did not yet surround the nucellus whereas in other cases they did.

No stages showing division of the megaspore mother-cell into dyad cells were seen during the investigation.

A linear tetrad of megaspores was the next stage observed (Fig. 2) The chalazal megaspore enlarges while the other three degenerate (Fig. 3). The arrangement of nucleus and vacuole in the chalazal megaspore seems to be constant. The nucleus is towards the micropylar end and the vacuole is chalazal (Fig. 2). When this megaspore is greatly enlarged there are vacuoles on either side of the central nucleus, said by Maheshwari (1937) (2) to be typical of this stage (Fig. 4).

The division of the chalazal megaspore nucleus to form a 2-nucleate embryosac was not observed nor was a 2-nucleate embryosac seen.

The 4-nucleate embryosac shows the typical arrangement of 2 nuclei at each pole, separated by a large central vacuole. Arrangement of the nuclei, however, seems to be unusual in that the orientation of the chalazal pair of nuclei is in the longitudinal axis of the embryosac whereas the micropylar nuclei lie, as usual, in the horizontal axis (Fig. 5). The resulting T-shaped arrangement of the nuclei might be correlated with the distinct narrowing of the embryosac at the chalazal end.

No typical 8-nucleate embryosac with 4 chalazal and 4 micropylar nuclei, separated by a central vacuole, was observed.

The Mature Embryosac. The arrangement of the nuclei is typical (Fig. 7).

The Egg Apparatus is slightly lateral in position. The synergids are elongate cells. The egg-cell generally is not so elongate as the synergids and lies close to them, usually below one of them. In some cases it is difficult to distinguish the egg-cell from the synergids due to its proximity to them and some similarity in appearance.

Generally the arrangement of vacuoles and nuclei in the cells of the egg apparatus appears typical. The vacuole in the egg-cell is towards the micropylar end with the nucleus below it and this arrangement is reversed in the synergids (Figs. 8 and 9).

The Polar Nuclei are usually situated more or less centrally between the egg apparatus and the antipodal cells. The polar nuclei are the largest in the embryosac.

Antipodals: In the recently mature embryosac (Fig. 7) the 3 antipodals in the narrow chalazal end may be seen as rather angular cells with irregular nuclear masses. Older embryosacs frequently show more than 3 antipodals. The irregular nuclear masses of antipodals in Fig. 15 may thus be interpreted as mitotic division figures of the nuclei. Fig. 15 shows multiple antipodals arranged in pairs which indicates that cells persist closely allied for some time subsequent to division. Frequently bi-nucleate antipodals were found (Fig. 12). Bi-nucleate antipodals were seen in both a healthy and a degenerate condition. The multiple antipodals are difficult to count and seem to vary in number from 6 to 14. The antipodals seem to degenerate at various stages.

Elongation of the Embryosac: The mature embryosac elongates beyond the antipodals into the chalazal nucellar tissue, the antipodals remaining in position (Fig. 11). Narrowing at the chalazal end persists, the embryosac widening out above this level. Thus a bridge of nucellar tissue extends across the embryosac at the original chalazal end. In some cases, the antipodals, in being left behind, become lateral to the embryosac.

The only Indications of Fertilization were seen in some of the most mature ovules investigated. These ovules show great increase in size (Fig. 13), the outer integument and outer layer of the inner integument are squashed. At the chalazal end of the ovule a cap of tannin-filled cells has developed. In some cases (Fig. 14) the micropyle is filled with pollentube remains, which are visible also within the embryosac. No male nuclei were seen. Frequently the darkly stained egg apparatus and remains of pollentube could not be sufficiently differentiated to make accurate observation possible.

C. **Restio dodii.**

Megasporogenesis was not observed since no material from very young buds was available.

The earliest stage observed was that of an enlarged chalazal megaspore with 3 degenerated megaspores (Fig. 16). From the position of these degenerated megaspores it is inferred that a sub-epidermal cell differentiated to become the megaspore mother-cell and that the result of meiosis was a usual linear tetrad of megaspores. At this stage the 2 integuments are not yet closed, but in all stages after this the integuments had closed. The enlarged megaspore shown in Fig. 16 is 19μ long and 10μ wide and its nucleus has 2 nucleoli.

Neither the division of the enlarged megaspore nor the 2-nucleate stage was observed.

A 3-nucleate stage of the embryosac (Fig. 17) was seen with a large vacuole separating the 2 mincropylar nuclei from the one chalazal nucleus. A 3-nucleate stage can be reached only by a non-synchronous division of the first two embryosac nuclei. Departures in the sequence of these divisions are usually in the nature of abnormalities that may occur now and then in any plant and have no special significance. Delayed division commonly occurs in the lowest part of the embryosac. (Maheshwari (1937) (2).)

Four-nucleate embryosacs (Fig. 18) were seen and it is probable that synchronous divisions are the rule, especially as spindle-fibres at each end of the embryosac were observed in one section. These 4 nuclei divide, as usual, to form the usual 8-nucleate embryosac (Fig. 19). An 8-celled stage was observed in which the nuclei are clearly separated by cell walls. This 8-celled stage was observed only once and may be regarded as a peculiar feature since we did not find references to any such 8-celled embryosac in the literature reviewed (Fig. 20).

The Mature Embryosac : The mature embryosac consists of an egg-cell, 2 synergid cells, 2 polar nuclei and always 3 or more antipodal cells, almost always uni-nucleate.

The Egg Apparatus : The egg and synergids are large and well developed, their nuclei being of approximately equal size. The egg is a spherical body lying between the 2 synergids (Fig. 24*b*) usually more to one side than the other (Fig. 24*b*). Often the egg lies over one of the synergids and seems to obliterate it (Fig. 25).

There was a marked difference in staining between the nucleus of the egg, synergids, polars and antipodals. Often the egg nucleus was completely decolorised, when the other nuclei were stained clearly. The synergid cells are slightly elongated, tapering towards the micropyle. Most often, one synergid was seen to be degenerating, while the other was still in a healthy condition (Fig. 24*c*). In many cases where there were no indications that fertilization had occurred (there were no pollen-tubes or pollentube remains and no male nuclei present) one synergid cell was seen to be degenerating, no nucleus was present, the cytoplasm was quite black in patches and the rest was coarsely granular and dark staining (Fig. 24*a*). Occasionally both synergids appeared to be degenerating with no nuclei present, before fertilization seemed to have occurred (Fig. 30). It seems that one synergid and occasionally both, begin to disorganize before fertilization. Similar phenomena have been reported by Regan (8) in *Agave virginica* where the synergids may occasionally disorganize before fertilization and by Murphy (4) in *Allium cernuum* where one synergid regularly disintegrates before fertilization.

Polar Nuclei are by far the largest of any in the embryosac. They may lie adjacent to the egg apparatus (Fig. 26) or some distance away (Fig. 25) but never in the centre of the embryosac. Fusion of the polar nuclei seems to be long delayed, since even in the stage of the fertilized egg nucleus, 2 adjacent polar nuclei are still present (Fig. 25). The nuclei were almost always seen close together, as if about to fuse (Fig. 26). Rarely was one nucleus found in the region of the polar nuclei. Since such a nucleus was found only where the egg was in division and no male nuclei were present, it was assumed to be the endosperm mother-cell (Fig. 31).

Antipodals : The first three antipodals divide irregularly, a number of times. Any number of antipodals, from 9 to 15, and possibly more, were observed, but the exact number could not be determined where many were present. Fig. 27*ab* shows about 11 nuclei. Fig. 29*f* about 14.

Most of the embryosacs studied showed more than 7 antipodals. The cells begin to degenerate just before or just after fertilization. The antipodals all apparently degenerate but the time of the onset of disorganisation shows no particular correlation with the stage of development or fertilization of the embryosac. (Fig. 23 *a b c*) are antipodals from a fertilized embryosac, (Fig. 27) from a mature unfertilized embryosac. The antipodal nuclei are slightly smaller than those of the egg apparatus.

Fertilization : All indications of fertilization were observed. Often pollen tube remains in the micropyle and pollen tubes in the ovary tissue, were observed (Fig. 35). Bodies that were almost certainly male nuclei were seen in several embryosacs (Figs. 25, 26, 33). Fig. 26 shows an egg nucleus in division, probably early metaphase and a male nucleus near the polar nuclei. The male nuclei are considerably smaller than those of the female. It seems that the egg is fertilized before triple fusion occurs (Fig. 26) and that the egg divides before the primary endosperm nucleus divides.

D. The ovules of the Restionaceae are pendulous (Pillans (5).) It was observed in *Elegia racemosa* and *Restio dodii* that the micropylar end of the embryosac faces not towards the stigma but towards the ovary stalk (Fig. 22). Thus the pollentube must grow down the side of the ovule and around the integuments at the micropylar end to reach the embryosac through the micropyle.

E. *Increase in Size of the Embryosac.*

In the early stages of development, the embryosac occupies less than half of the nucellus and is found only in the micropylar end of the ovule. When mature, the embryosac fills almost the entire ovule, except in the chalazal region, where the embryosac never extends to the region from which the integuments arise.

In the micropylar region, the nucellar tissue covering the embryosac is only one cell thick and occasionally two cells. The most marked and most rapid increase in size, particularly the length, in *Restio dodii*, takes place from the 8-nucleate stage to the mature embryosac.

The mature embryosac of *Restio dodii* varies from 275μ to 350μ in length.

F. *The Integuments and Tannin Deposition.*

The 2 integuments are each two cells thick, except over the micropyle, where they may be several cells thick, especially the outer integument. In *Restio dodii*, tannin appears in the inner layer of the inner integument after the primary 8-nucleate stage. This layer is continuous in both *Restio dodii* and *Elegia racemosa*, except in a small region over the micropyle, where there is no tannin at all. In late maturation stages the region of tannin in the chalaza tends to become larger and an area of tannin-filled cells is found at the base of the chalaza (Fig. 22). In all stages tannin is present in the ovule epidermis.

G. *Failure of Embryosac Formation.*

A few ovules were found in which no megaspore mother-cell or any product of its divisions were found. Fig. 34 illustrates such an ovule. It will be seen that the integuments are completely closed—a stage in which an embryosac should have been formed—and that tannin has appeared in the inner layer of the inner integument and occasionally in the outer layer of that integument. The centre of the ovular tissue shows a small area of tannin-filled or degenerate cells.

Ovules were found with relatively large embryosacs devoid of contents or with blackened and degenerate contents. Increased tannin development was frequently observed in the region of insect bites.

The occasional failure of the formation of reproductive cells has been noted by other workers. Among others, Regan (8) in Agave found many of the ovules formed no reproductive cells at all and were sterile and abortive.

V. DISCUSSION.

The normal course of development has been found in the vast majority of Angiosperms investigated thus far (Maheshwari, Schnarf and Wettstein). There are deviations within the normal course of development which occur chiefly in tetrad formation, divisions of the megaspore nucleus and organization of the embryosac (Maheshwari, Schnarf and Wettstein). In *Elegia racemosa* and *Restio dodii* minor deviations are seen in the behaviour of the antipodals and in the extensive elongation of the embryosac in the former.

Schnarf (1929) (10) emphasizes the fact that the antipodals are the most variable constituent of the embryosac, in number, form of cell and nucleus and in persistence. He considers that antipodals play a significant nutritive role in species in which this tissue is well developed. In *Restio dodii* the antipodals are always numerous and appear to persist into fertilization stages. These facts seem to indicate that the antipodals contribute in one manner or another to nutrition of the embryosac and the embryo.

Antipodals in *Elegia racemosa* multiply at random to form, in some cases, a fairly prominent tissue. In other cases, however, degeneration of the antipodals occurs before endosperm formation is initiated. Thus the possible nutrient value of the antipodals in this case needs further investigation.

A large number of workers report that the grass embryosacs usually contain numerous antipodal cells (Stover 11). The large number of antipodals found in *Elegia racemosa* and *Restio dodii* may indicate some alliance between the Gramineae and the Restionaceae embryosacs.

The elongation of the embryosac in *Elegia racemosa* would tend to strengthen this alliance. Elongation of the embryosac above the antipodals into the chalazal nucellar tissue is described by Stover (11) as a typical feature of some Gramineae members. Elongation is extensive, the embryosac becoming as much as twice its original length, as was also found to be the case in *Elegia racemosa*. Almost complete absorption of nucellar tissue noted by Stover was not observed in *Elegia racemosa*. Antipodals also do not become typically lateral in position to the embryosac as is quoted for grasses, though in some cases lateral disposition was observed.

Elongation of the embryosac has been observed also in several members of the Centrospermales, by Maheshwari (2). The embryosac elongates at the chalazal end, absorbing its way through the nucellus and pushing forward while the antipodal cells remain *in situ* and are relegated to a lateral position. This elongation which has been found in a certain number of plants seems to be a very effective haustorial organ.

Tannin in the ovary wall and its development within the inner layer of the inner integument, is a conspicuous feature in ovule development in both *Elegia racemosa* and *Restio dodii*. Thatcher (12) thinks that tannins probably do not serve in any significant way as food materials. They are usually elaborated when intense metabolism is taking place or in rapid tissue formation. Tannins may also act as protective agents, as for example against parasite fungi.

They have also been associated with lignin formation, lignification occurring in those cells where tannin was earlier deposited. This would seem to be the case in the *Restio dodii* fruit which is enclosed in a tough hard covering. In *Elegia racemosa* it was found to be most difficult to section old ovaries because of their hardness due to tannin deposition and subsequent lignification.

VI. Conclusion.

The development of the embryosac in both *Restio dodii* and *Elegia racemosa* corresponds to the normal type, its egg-cell being removed from the megaspore mother-cell by 5 divisions, and only one megaspore taking part in the embryosac formation. The total number of nuclei in the mature embryosac is greater than the usual eight, due to the presence of more than 3 antipodal cells. The antipodals multiply vegetatively, resulting in a condition which has no special significance in the classification of embryosac types. The antipodals may however, be of importance in nutrition of the embryosac, in view of their occasional persistence in an apparently healthy condition late in embryosac development. This deviation which occurs in antipodal behaviour in both plants, and elongation of the embryosac in *Elegia racemosa*, may serve, however, to strengthen an association between Restionaceae and Gramineae.

VII. SUMMARY.

Embryosac formation in both *Restio dodii* and *Elegia racemosa* was found to follow the normal course of development.

In *Elegia racemosa* the following stages were observed :—

1. Differentiation of megaspore mother-cell.
2. Linear tetrad of megaspores.
3. Enlarged chalazal megaspore.

The 4-nucleate stage was noted in both plants, while the 8-nucleate stage was observed in *Restio dodii* only. The mature embryosac shows the normal arrangement of egg-cell, synergids and polar nuclei.

Antipodals are numerous in both cases, appearing to multiply vegetatively. In *Restio dodii*, in one case only, an 8-celled embryosac was observed. Elongation of the embryosac was seen to occur in *Elegia racemosa*. Fertilization was observed in *Restio dodii*, where the polar nuclei are not fused even after fertilization.

Tannin development in the ovary wall and in the inner layer of the inner integument is marked in both plants.

ACKNOWLEDGEMENTS.

The authors wish to thank Professor J. F. V. Phillips for facilities provided in his Department at the University of the Witwatersrand.

Dr. S. Krupko wishes to thank the C.S.I.R. whose grant made possible the collection of material from the Cape in December, 1946 and January, 1947. He is greatly indebted to Prof. R. H. Compton for his help in indication of plant habitats on the Cape Peninsula and much important advice, to Prof. R. S. Adamson for permission to use the facilities in his Department for the fixation of the material, to Mr. N. S. Pillans for the naming of the plants and to Miss E. Esterhuysen for help in collection of the material.

EXPLANATION OF PLATES.

Figs. 1—15 *Elegia racemosa*. *Figs.* 16—35 *Restio dodii.*

All drawings were made with a Zeiss camera lucida. For drawings of *Elegia* *racemosa* a Bausch and Lomb microscope with the following lenses was used :—Obj. 10 ×, 43 ×, 97 × ; oc. 10 ×.

Drawings of *Restio dodii* were made using a Leitz microscope with obj. 3 ×, 7 ×, 1/12 (oil immersion) and a 4 × oc. The Bausch and Lomb condensor had an n.a. of 1.25, the Leitz of 1.3.

Figs. 1, 2, 3, 4, 6 .. 150 × ; Figs. 7, 13 .. 800 × ; Figs. 5, 8, 9, 10, 11, 12, 15 .. 1,700 × ; Figs. 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 28, 29, 30 .. 1,600 × ; Figs. 21 .. 1,300 × ; Fig. 22 .. 140 × ; Figs. 34, 35 .. 600 ×.

Abbreviations :—

ac.	antipodal cell.	m.	micropyle.
an.	antipodal nucleus.	mn.	male nucleus.
cc.	chalazal end.	n.	nucellus.
c.m.	chalazal megaspore.	o.	ovary tissue.
c.n.	chalazal nucleus.	o.i.	outer integument.
e.	egg.	p.n.	polar nucleus.
e.s.	embryosac.	pt.	pollen tube remains.
e.es.	elongation of embryosac.	s.	synergid.
i.i.	inner integument.	t.i.	tannin of inner integument.

Fig. 1. Megaspore mother-cell directly beneath nucellar epidermis.

Fig. 2. Tetrad of megaspores.

Figs. 3 and 4. Enlarged chalazal megaspores.

Fig. 5. Four-nucleate embryosac.

Fig. 6. L.S. ovule in the four-nucleate stage.

Fig. 7. Mature embryosac.

Fig. 8. Egg-cell in micropylar end of embryosac.

Fig. 9. Synergids in micropylar end of embryosac.

Fig. 10. Portion of embryosac with polar nuclei and three antipodal cells.

Fig. 11. Elongation of the embryosac into nucellar tissue. Note position of antipodals.

Fig. 12. Bi-nucleate antipodals.

Fig. 13. Entire ovule showing empty embryosac and elongation of embryosac.

Fig. 14. Micropylar end of an ovule showing evidences of fertilization.

Fig. 15. Multiple antipodals.

Fig. 16. Enlarged chalazal megaspore.

Fig. 17. Three-nucleate embryosac.

Fig. 18. Four-nucleate embryosac.

Fig. 19. Eight-nucleate embryosac.

Fig. 20. Eight-celled embryosac.

Fig. 21. Portion of ovule showing integument development and micropyle.

Fig. 22. L.S. entire ovule showing size and position of embryosac.

Fig. 23. A.B.C. Consecutive sections showing multiple antipodals.

Fig. 24. A.B. Consecutive sections showing egg-cell, synergids and polar nuclei.

Fig. 24. C. Compound drawing of 24 A. and B.

Fig. 25. Egg-cell, synergids, polar nuclei and possible male nuclei from a mature embryosac.

Fig. 26. Egg-cell, one synergid, polar nuclei and male nuclei from a mature embryosac.

Fig. 27. L.S. entire ovule showing remains of pollentube in micropyle.

Fig. 28. A.B.C. Egg-cell, one synergid, polar nuclei, remains of pollentube and male nucleus of mature embryosac.

Fig. 29. A.B.C.D.E. Consecutive sections showing antipodals.

Fig. 30. Contents of a mature embryosac showing egg apparatus and polar nuclei.

Fig. 31. Contents of a mature embryosac.

Fig. 32. A.B.C.D.E. Consecutive sections showing multiple antipodals.

Fig. 33. Ovule in which no embryosac developed.

Fig. 34. Contents of mature embryosac. Blackened synergids.

Fig. 35. Micropyle with pollentube remains.

BIBLIOGRAPHY.

1. Engler and Prantl : Die Naturlichen Pflanzenfamilien. W. Engelmann, Leipzig (1930).
2. Maheshwari, P. : Critical Reviews of the types of Embryosacs in Angiosperms. *New Phytologist*, Vol. 36 (5) p. 259—417 (1937).
3. Maheshwari, P. : Recent work on the types of Embryosacs in Angiosperms. *Jour. Indian Bot. Soc.* : *Vol.* 20, p. 223—261 (1941).
4. Murphy, J. B. : Embryosac development in *Allium cernuum* Roth. *Amer. Jour. Bot.*, Vol. 33 (3), p. 221 (1946).
5. Pillans, N. S. : African genera and species of *Restionaceae*. *Trans. Roy. Soc. South Africa*, Vol. 16, Parts 3 and 4.
6. Pillans, N. S. : New species of South African *Restionaceac*. *Trans. Roy. Soc. South Africa*, Vol. 29, Part 4 (1942).
7. Pillans, N. S. : New and hitherto imperfectly known species of African *Restionaceae*. *Trans. Roy. Soc. South Africa*, Vol. 30, Part 3 (1945).
8. Regan, L. : The development of the Embryosac in *Agave virginica*. *Bul. Torrey. Bot. Club*, Vol. 68, p. 229—236 (1941).
9. Schnarf, K. : Contemporary understanding of Embryosac development among Angiosperms. *Bot. Rev.*, Vol. 2 (12), p. 565—582 (1936).
10. Schnarf, K. : Archegonium and Archegon theory *Biol. Gen.* (Vienna) 16. (1/3), p. 198—224 (1942). *Biol. Abs.* (March, 1947).
11. Stover, E. L. : The Embryosac of *Eragrostis cilianensis* (All.) Link.—A new type of Embryosac and a summary of Grass Embryosac investigations. *Ohio Jour. Sci.*, Vol. 37.
12. Thatcher, R. W. : Chemistry of Plant Life. (Chap. 7 : tannins). *McGraw Hill* (1921).
13. Wettstein, R. : Handbuch der Systematischen Botanik, 4th Ed. (1935) (Wien and Leipzig).

PRINTED BY CAPE TIMES LIMITED, KEEROM STREET, CAPE TOWN.

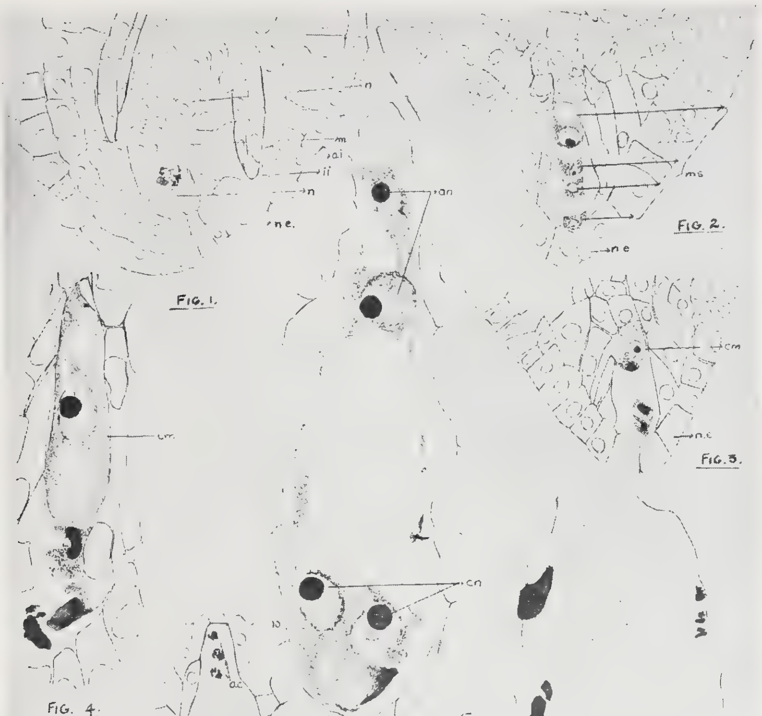

Plate I. Restionaceae.

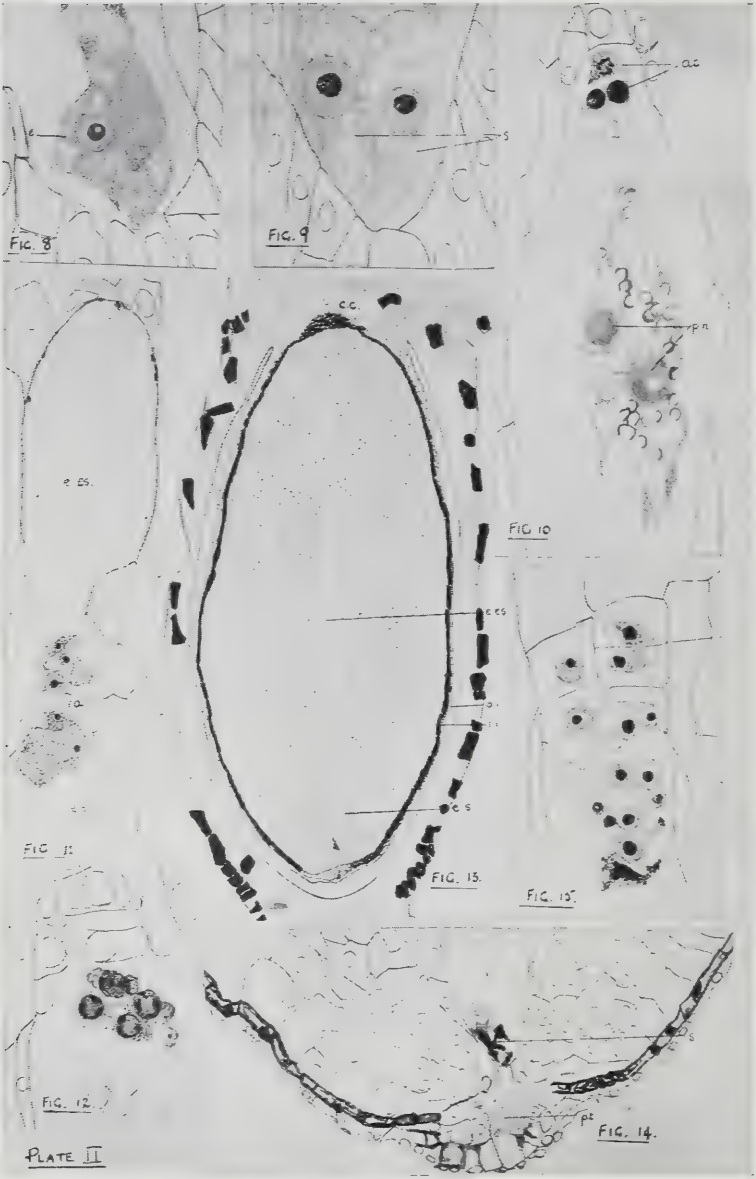

Plate II. Restionaceae

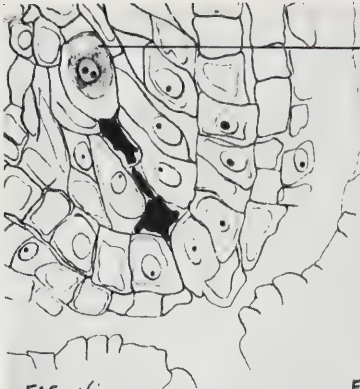

FIG 16

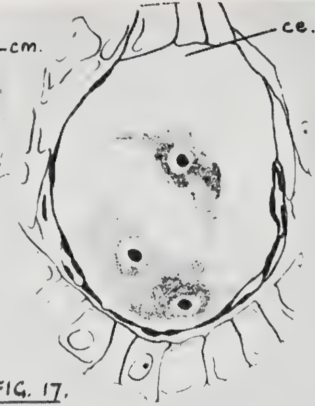

FIG. 17.

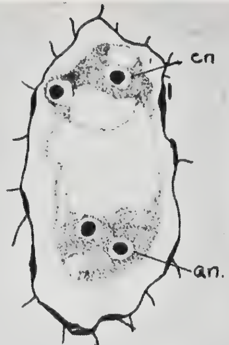

FIG. 18

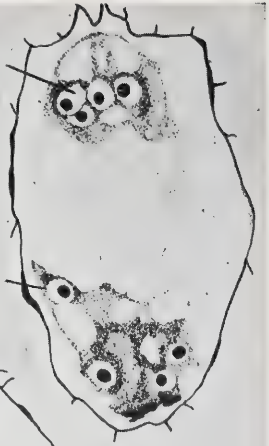

FIG. 19.

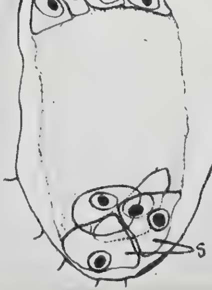

FIG. 20

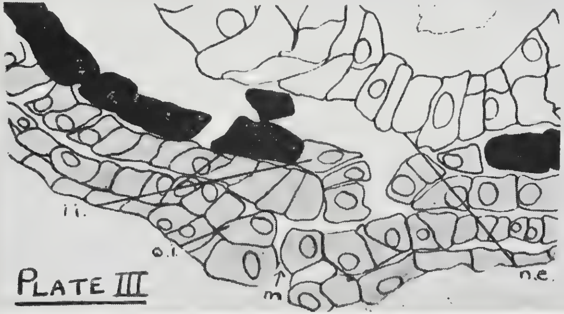

FIG. 21.

PLATE III

Plate III. Restionaceae.

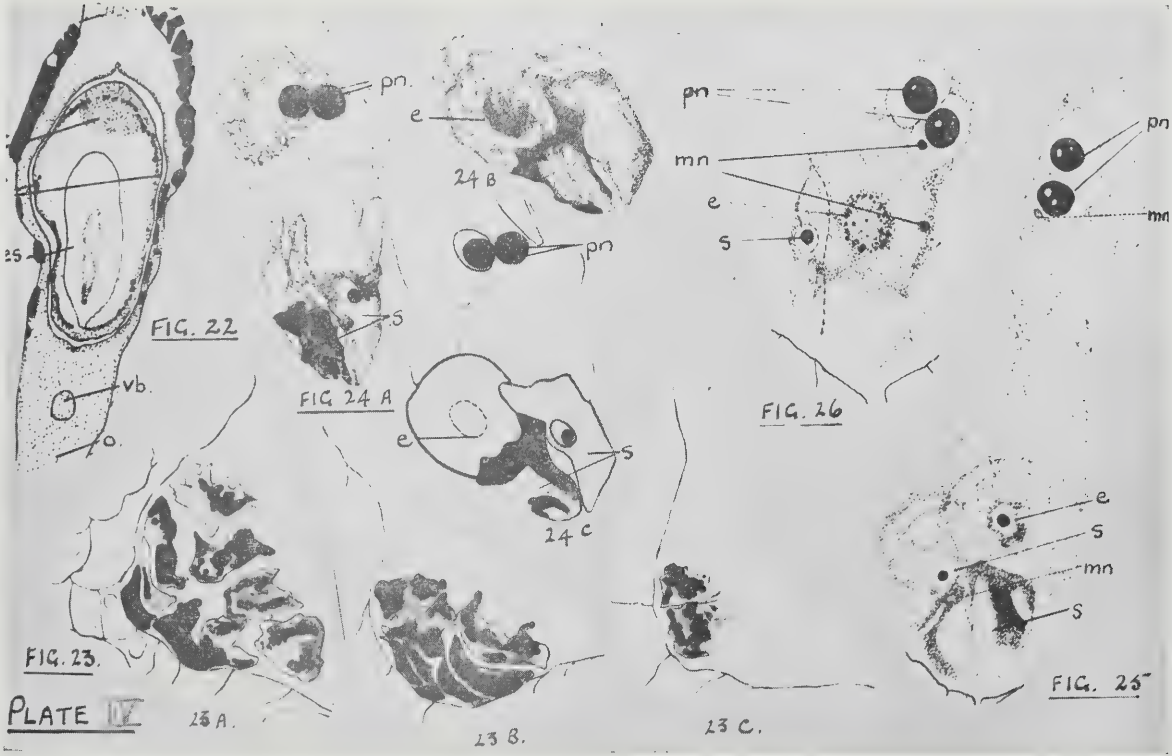

Plate IV. Restionaceae.

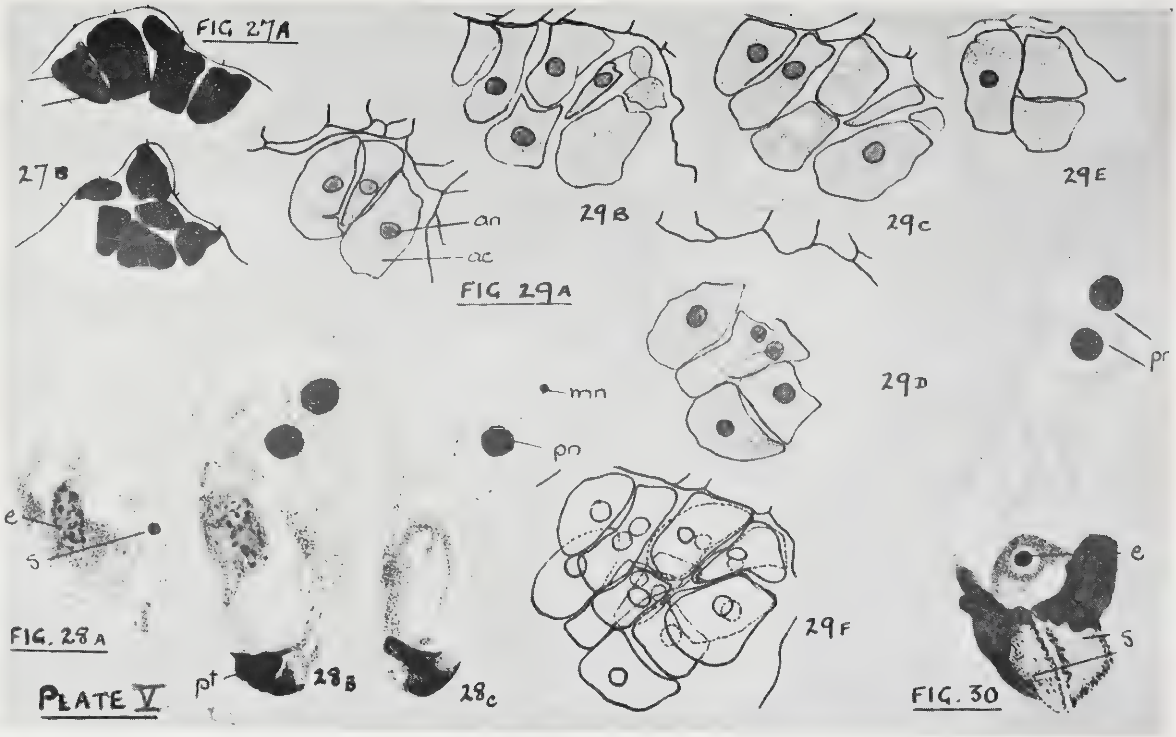

Plate V. Restionaceae

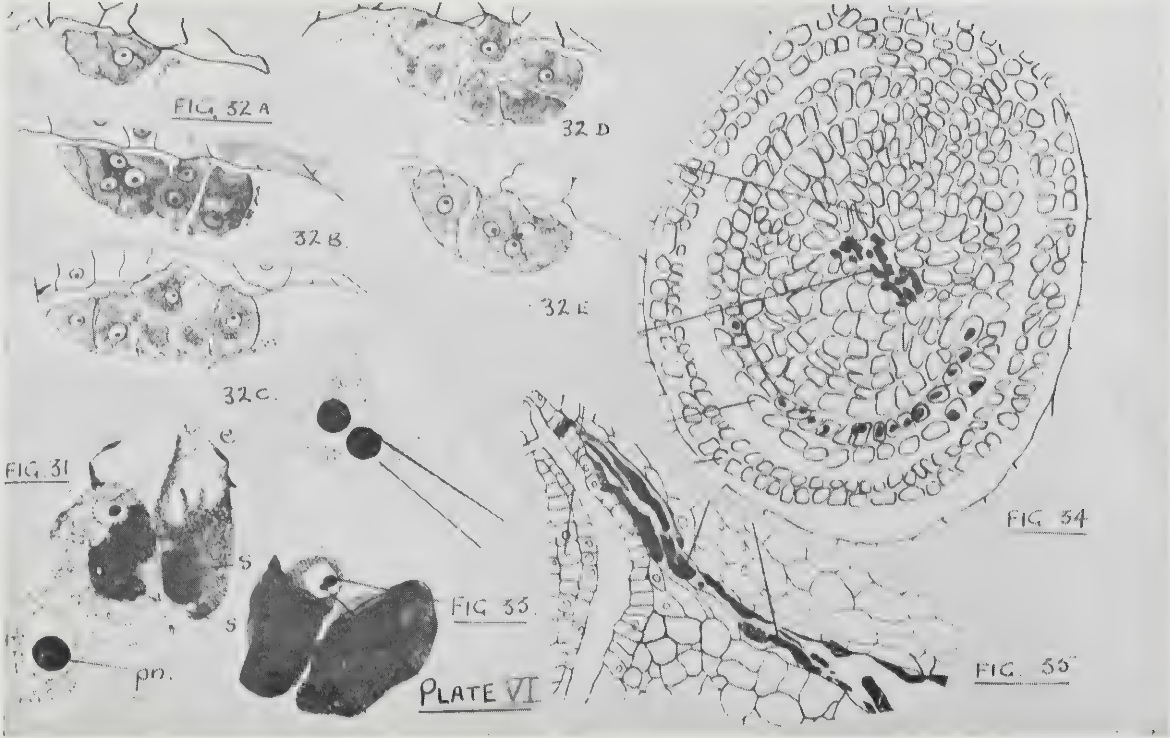

Plate VI. Restionaceae.